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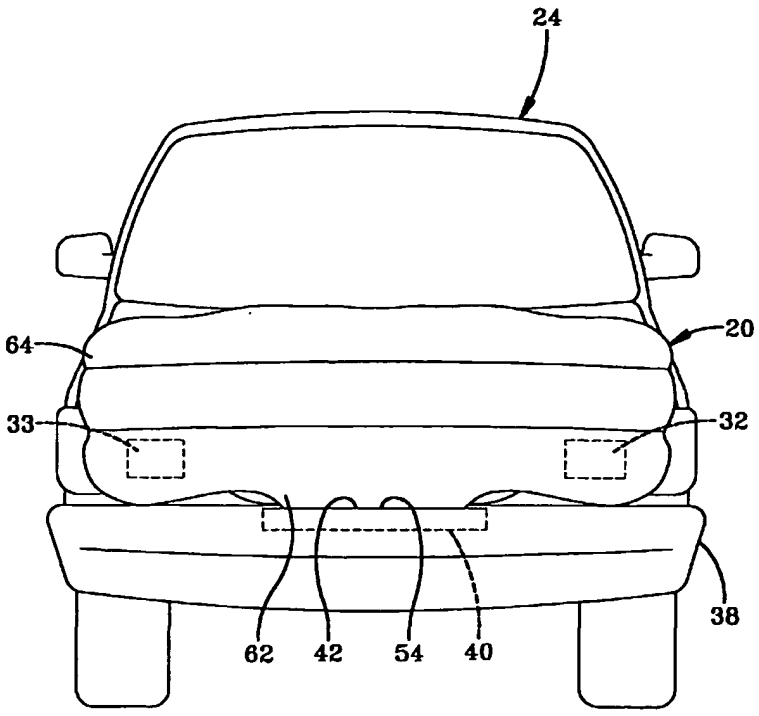
(54) Title: VEHICLE FRONTAL AIRBAG SYSTEM



(57) Abstract: The present invention comprises an external airbag system for mounting on a vehicle (24) that deploys into the region above the bumper (38) to prevent or mitigate injuries that would have otherwise been caused by a person striking the grill (28) or hood area (26) of the vehicle. The airbag (20) is stored in a housing (40) mounted within the front bumper (38) of the vehicle. The airbag (20) is deployed upwardly through an opening (42) in the upper surface of the bumper (38) into the region between the upper surface of the bumper (38) and the front surface fo the grill (28) and hood (26). The airbag (20) is generally T-shaped and includes a plurality of internal tethers (30,31) extending internally between the opposing inner surfaces (74) at regular intervals to cause the airbag (20) to be tufted. The internal tethers (30, 31) reduce the volume of the airbag (20) for a given frontal area thereby decreasing the inflation time required, without resort to fabricating the airbag (20) from multiple idependent chambers. Selected of the internal tethers (31) may be designed to break as the airbag reaches close to its full inflation pressure to allow a portion of the airbag to bulge outwardly after the air bag is fully deployed. The remaining tethers (30) are designed to break as the pressure increases when the airbag is collapsed in a collision.

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Vehicle Frontal Airbag System

Background of the Invention

This invention relates generally to motor vehicle safety devices and in particular to inflatable airbags.

For many years the automotive industry has tried various products and methods to reduce injury to passengers and vehicles in collisions. Such products and methods have included energy absorbing bumpers, seat belts and inflatable airbags. Typically, inflatable airbags have been located in the steering column and dashboard. More recently, side impact airbags have been located in the frame surrounding the door or on the seat belt itself. The aforementioned interior-disposed airbags are directed primarily to preventing injury to the occupants of the vehicle in a collision, but do nothing to mitigate injury to the occupants of other vehicles involved in the collision, or to pedestrians who are struck by the vehicle.

External airbags have been proposed that deploy between the front bumper of the impacting vehicle and the vehicle being struck in order to reduce the severity of the impact and thereby reduce the severity of the vehicle damage and occupant injury. For example, U.S. Patent No. 5,725,265 to Baber discloses an airbag concealed inside the rear bumper of a truck that is inflated and extends rearwardly from the bumper to reduce the effects of the impact. The bumper has a breakaway panel on the outer surface of the bumper that is removed by the inflation of the airbag. U.S. Patent 6,126,214 to Kim discloses an air inflatable bumper having a bladder that inflates in response to an impact and extends outwardly from the bumper frame. U.S. Patent No. 6,056,336 to Balgobin discloses a bumper airbag having an internal shock absorber. The airbag is deployed in a generally spherical shape forward of the bumper. U.S. Patent No. 6,450,556 to Jacobs

teaches an airbag mounted to the rear of a truck that deploys in response to the bending of the under-ride guard mounted at the rear or side of the truck. U.S. Patent No. 5,732,785 to Ran, et al. discloses a proactive vehicle safety system consisting of plural airbags deployable around the perimeter of a vehicle that deploy in response to an impending impact.

The increased popularity of sport utility vehicles (SUVs), passenger trucks and other motor vehicles that stand higher than a standard automobile, has created new problems in the field of vehicle collision safety. Specifically, when one of these higher than standard vehicles broadsides a standard automobile, because of the difference in height between the two vehicles, the bumper of the higher vehicle will contact the standard automobile above the reinforced area of the door. In such cases it is possible for the upper body and head of the occupant of the struck vehicle to impact the grille or hood of the higher vehicle. Similarly, when a high profile vehicle strikes a pedestrian, in many cases the impact of the pedestrian's head against the grille and hood area causes more severe injuries than the initial impact between the bumper and the lower extremities of the pedestrian.

United States Patent No. 6,474,679 to Miyasaka, et al. discloses an airbag system that deploys a pair of airbags from beneath the cowl area of a standard automobile to cover the A-pillars of the vehicle in response to a collision. The airbags prevent a pedestrian that has been struck by a vehicle from sliding up the hood and being injured by impacting the vehicle A-pillar. Although Miyasaka recognizes the importance of deploying external airbags to mitigate injuries to struck pedestrians, the airbag system disclosed by Miyasaka is suitable only for automobiles with sharply sloped hoods. High profile vehicles and vehicles with more rectangular outlines such as SUVs would not

benefit significantly from airbags deployed over the A-pillars because a pedestrian struck by such a vehicle is generally injured by impact with the grille and leading edge of the hood not by impact with the vehicle A-pillars. Accordingly, what is needed is an airbag that deploys in the region above the bumper and forward of the grille to mitigate injuries to persons struck by such vehicles.

Summary of the Invention

The present invention comprises an external airbag system for mounting on a vehicle such as an SUV that deploys into the region above the bumper to prevent or mitigate injuries that would have otherwise been caused by a person striking the grille or hood area of the vehicle. According to one embodiment of the invention, the airbag is stored in a housing mounted within the front bumper of the vehicle. The airbag is deployed upwardly through an opening in the upper surface of the bumper into the region between the upper surface of the bumper and the front surface of the grille and hood of the vehicle. In one embodiment of the invention, the airbag is generally T-shaped extending upward and outward from the housing to cover substantially the entire grille and leading edge of the hood. The airbag includes a plurality of internal tethers extending internally between the front wall and the back wall at regular intervals to cause the front and rear surface of the airbag to be tufted. The internal tethers reduce the volume of the airbag for a given frontal area thereby decreasing the inflation time required, without resort to fabricating the airbag from multiple independent chambers. Selected of the internal tethers may be designed to break as the airbag reaches close to its full inflation pressure to allow a portion of the airbag to bulge outwardly after the airbag is fully deployed. The remaining tethers are designed to break as the pressure increases when the airbag is collapsed in a collision. Optionally, an airbag constructed in

accordance with the present invention includes a plurality of external tethers attached to the rear surface of the airbag which, as the airbag inflates, are tensioned to cause the airbag to bow rearwardly to cover fully the high crown area of the leading edge of the hood.

Brief Description of the Drawings

The drawing figures are intended to illustrate the general manner of construction and are not necessarily to scale. In the detailed description and in the drawing figures, specific illustrative examples are shown and herein described in detail. It should be understood, however, that the drawing figures and the detailed description are not intended to limit the invention to the particular form disclosed, but are merely illustrative and intended to teach one of ordinary skill how to make and/or use the invention claimed herein and for setting forth the best mode of carrying out the invention.

Fig. 1 is a front view of one embodiment of a frontal airbag;

Fig. 2 is a side view of Fig. 1 illustrating the airbag being inflated showing the external tethers before the airbag is fully inflated;

Fig. 3 illustrates the external tethers of Fig. 2 bending the airbag over the front of the hood;

Fig. 4 is a perspective view of the front end of a motor vehicle illustrating the frangible airbag cover;

Fig. 5 is a perspective view of the frontal airbag module;

Fig. 6 is a partial rearview of the module mounted on the bumper;

Fig. 7 is a front prospective view of another embodiment of the invention;

Fig. 8 is a sectional side view of the inflated airbag of Fig. 7;

Fig. 9 is a pattern for the airbag of Fig. 7; and

Fig. 10 is a schematic of a control system for the invention.

Detailed Description of the Invention

The herein frontal airbags of the various embodiments have a dual purpose:

(1) The first purpose is that of reducing injury of an occupant caused by vehicle bumper height incompatibility. This is found when a truck-type vehicle, such as a SUV, crashes into the side of an automobile. In a crash wherein the struck vehicle is struck broadside by the striking vehicle, there is a tendency for the head of the occupant of the struck vehicle to hit the hood or some part of the front of the striking vehicle causing injury to the head.

(2) The second purpose is to reduce injury to pedestrians who are hit by the striking vehicle. The frontal airbag protects the pedestrian from potentially severe injury due to striking hard surfaces including the grille 28 and the front of the hood 26 of the motor vehicle 24.

There are at least four unique features of the embodiments of a frontal airbag constructed in accordance with the teachings of the present invention.

(a) The first is that the airbag deploys vertically against gravity.

(b) The second is that the airbag has internal tethers 30 interconnecting the front surface of the airbag to the rear surface of the airbag at regular intervals to create a tufted surface. The tufting reduces the total volume of the airbag for a given surface area, enabling the airbag to deploy more rapidly, without resort to incorporation of multiple chambers within the airbag.

(c) The third is that the airbag has frangible internal tethers 31 located in the central region that are designed to break during inflation allowing

the airbag to expand in its center portion once the airbag is fully deployed and reaching its full inflation pressure.

(d) The remaining internal tethers 30 are also designed to break at a higher pressure than the frangible internal tethers 31 such that during a collision as the pressure within the airbag exceeds the maximum inflation pressure, the internal tethers 30 break expanding the volume to lower the pressure in the airbag down to the required level, thus managing the energy in a vehicle crash.

Referring to Fig 1, there is illustrated a front view of a motor vehicle 24 showing one embodiment 20 of a vehicle frontal airbag system. Plural crash sensors 32, 33 are mounted on the motor vehicle and adapted to sense the presence of an object about to collide with the motor vehicle. The sensors 32, 33 are electrically connected to an electronic control unit 34, "ECU", as are pluralities of vehicle sensors 36 responsive to vehicle engine operating parameters. The electronic control unit 34, not shown, is mounted to the firewall or inside of the passenger compartment of the motor vehicle 24, and responds to the crash sensors 32, 33 and the vehicle sensors 36 for determining that a collision is about to happen and deploying the frontal airbag 20.

A bumper member 38 is mounted on the motor vehicle 24 with the inside surface 58 of the bumper 38 facing the front of the motor vehicle 24 and the outside surface of the bumper facing away from the front of the motor vehicle in the direction the vehicle is generally traveling forward.

A module member 40, Figs. 5-6, is mounted behind and adjacent to the inside surface of the bumper member 38. The module member 40 has an aperture or opening 42 in one, typically the top, surface so that when it is mounted the opening 42 is aligned in a direction that is facing upward relative to the normal position of the motor vehicle 24.

A frangible cover 44, Fig. 4, encloses the aperture or opening 42 and is mounted on the module 40. An inflation fluid connector 46 is mounted on the module 40 on the side closest to the grille 28. The frangible cover 46 is designed to fit tight to the bumper 38 and the module 40 has a bracket or cover ring 48 surrounding the frangible cover 44 to hold the module 40 tight to the bumper 38.

The inflation fluid connector 46 is adapted to receive inflation fluid from an inflator 50, 52 that may be mounted on the module 40 or located on the vehicle and connected to the connector 46 by a high-pressure hose. The inflator 50, 52 is also electrically connected to the ECU 34. Illustrated in Figs 5 and 6 are both a cylindrical inflator 50 and a pancake inflator 52. The selection of the type of inflator is up to the airbag designer. Either or both may be used.

Located in the module member 40 is an inflatable frontal airbag 20 that is securely connected to the module member 40 and adapted to receive inflation fluid from the inflator 50, 52 through the inflation fluid connector 46. In one embodiment, Figs. 1-3, the frontal airbag 20 may be fabricated from a pair of sheets of fabric, or a single sheet folded over, that have a pair of opposite sides held together by stitching substantially around the perimeter leaving an open throat 54 at the bottom. The frontal airbag 20 is accordion folded and placed within the module member 40 such that the throat of the airbag is operatively connected to receive the inflation fluid.

The frangible cover 44 functions to restrain the uninflated folded airbag and when the airbag is inflated, the frangible cover 44 is broken allowing the airbag 20 to be deployed. The electronic control unit 34, Fig. 10, responds to at least one sensor 32 or 33 indicating a potential crash between the motor vehicle 24 and a struck vehicle and by

means of an appropriate algorithm 56 causes the folded frontal airbag 20 to inflate and break through the frangible cover 44.

Figs 4 and 6 illustrate a bumper 38 having an opening intermediate its ends. The module 40 is mounted against the inside 58 of the bumper 38 and the opening 42 in the module 40 is aligned with the opening in the bumper 38. The frangible cover 44 overlies the opening in the bumper, hence the opening 42 in the module 40. The frangible cover 44 is secured by means of fasteners 60 such as bolts and nuts.

Typically at least two sensors 32, 33 are mounted in a spaced apart relationship on the front of the motor vehicle 24 to sense the approach of another vehicle or object. The algorithm 56 in the electronic control unit 34 is designed to determine the characteristic of the approaching vehicle or object in a manner well known in the art. The algorithm 56 will, from the information generated by the sensors 32, 33 determine when to inflate the airbag 20.

As illustrated in Fig. 1, the frontal airbag 20 when inflated is generally T-shaped with the vertical member 62 of the T-shaped airbag extending from the throat 54 and the aperture 42 in the module 40. The cross-arm member 64 of the T-shape extends across the grille 28 of the motor vehicle (although the illustrative embodiment shows a conventional grille, as used herein grille means and refers to the region of the vehicle immediately behind the bumper, whether it be a conventional grille, light array or sloped portion of the hood.) As shown in Figs. 2-3, the cross-arm member 64 has a plurality of inflated cylindrically shaped rows 66. Optionally, Fig. 2-3, a plurality of external tethers 68 is connected between the rear surfaces of at least two of the uppermost cylindrically shape rows 66. As the rows inflate, the external tethers 68 cause the uppermost two rows to bend over the top portion of the vehicle grille 28 and cover the forward edge of the

hood 26. Without the optional external tethers 68, the airbag 20 will extend vertically and the force of the object hitting the airbag 20 will cause the airbag to deflect over the edge of the hood 26.

In another embodiment, as shown in Fig. 7, the inflatable airbag 22 is T-shaped when inflated with the vertical member 70 of the T-shaped airbag 22 extending from the throat 54. The cross-arm member 72 of the T-shaped airbag 22 extends vertically in front of the grille 28 of the motor vehicle 24. There is a plurality of internal tether members 30, Fig. 8, located between the opposed inner surfaces 74 of the opposite sides of the airbag 22 tending to hold the shape of the airbag 22 until the pressure increases and the internal tethers 30 break allowing the airbag 22 to expand. The inflation pressure between 7-9 psi, in the airbag 22 maintains it in a vertical orientation from the opening in the bumper 38 holding the airbag 22 in front of the grille 28 of the motor vehicle 24.

Fig. 6 shows the module 40 mounted to the vehicle bumper 38 with a frangible cover 44 enclosing a non inflated airbag stored therein. An inflator 50 or 52 is responsive to the ECU 34 control system and operates to inflate the airbag 22 for opening the frangible cover 44 and deploying now inflated airbag across the grille 28 at the front of the vehicle 24.

Depending upon the design of the algorithm 56 which is not the subject of this invention, the sensors 32, 33 deployed on the front of the motor vehicle 24 may be of many types such as an infrared sensor or a capacitive sensor. This is a choice of the system designer.

Fig. 5 illustrates the module 40 being a rectangular-shaped member having first 74 and second 76 elongated side plates or members. The third 76 and fourth 77 end plates or members and fifth 78 bottom plate or member complete the enclosing of the module

40 except for the open top. All of the members 74-78 are rigid members connected together to form the rigid rectangular-shaped member having an open top. In the preferred embodiment, all of the members 74-78 are steel. Connected to one of the elongated rigid side members 75 is an inflation fluid connector 46.

The frangible cover 44 is fastened to the module 40 to enclose the open top. In Fig. 6, the frangible cover 44 is spaced from the open top to allow the top bumper panel 80 to fit between a cover ring 48 and the frangible cover 44. The cover ring 48 operates to hold the rigid module 40 in position on the vehicle 24.

Extending from the side members 74-78 is a plurality of holders or fasteners 82 for securing stored folded frontal airbag 22 to the module 40. When the module 40 is secured to the motor vehicle 24, the frangible cover 44 faces upward in the direction of the grille 28 of the motor vehicle. In Fig. 7, upon inflation of the frontal airbag 22, the frangible cover 44 is burst open and the airbag 22 moves out of the module 40 and spreads up and across in front of the grille 28. In one embodiment, Fig. 1, the airbag 20 folds over the front of the hood 26 and in another embodiment, Fig. 7, the frontal airbag 22 remains vertical in front of the grille 28.

Fig. 9 illustrates one embodiment of the frontal airbag 22. This embodiment is typically fabricated from sheet material having a first sheet of material having at least one side being coated. The second sheet of the material has a shape that is congruent with the first sheet and also has at least one side coated. In the preferred embodiment, the coating is silicone. The shape of both sheets is in the form of a "T". The coating is for sealing the airbag 22 and being silicone or urethane to provide a smooth surface to facilitate deployment of the airbag 22. In the alternative, instead of two separate sheets,

the airbag may be fabricated from a single sheet first folded in half and then the shape is formed.

A plurality of internal tethers 30, represented by open arrows 85 in Fig. 9, are each sewn at their respective ends to each of the uncoated sides. Similarly a plurality of frangible internal tethers 31 represented by arrows 87 are attached in the region represented by the dashed line 92. The internal tethers 30 and 31 form a plurality of rows, in the preferred embodiment five rows of internal tethers 30 and 31 separated by five blank rows. Each row is substantially parallel to the cross-arm of the "T".

The first and second sheets are positioned to overlie each other so that the uncoated sides are facing each other. The perimeter edges 86 of the two overlying sheets are sewn together except across the base of the vertical arm 70 of the T-shape that forms the throat 54. The rows, which are ten in the preferred embodiment, are folded together in an accordion fold extending from the top of said cross-arm toward the throat 54.

The fabric of one embodiment of the airbag is 525 denier with a silicone coating; the fabric of the internal tethers 30 and 31 are 840 denier with either a silicone coating or a urethane coating on both sides of the fabric. The stitching for the perimeter and the tethers is "Double Needle Chain Stitch "DNCS" with 138 SPECTRA thread available from Honeywell, Inc. (formerly Allied Thread) of Morristown, NJ.

Referring to Fig. 9, the first step is to secure a sheet of the fabric 64 for the piece about to be cut and then cut out the pattern for that piece. Next mark horizontal lines 88 on the each sheet of the airbag fabric 84 to represent the fold lines. These fold lines 88 are spaced a distance as determined by the airbag designer. It has been found that by pressing the lines 88 to cause a fold, folding of the airbag 22 is greatly enhanced. Then, sew a reinforcing strip 90 of 525 denier fabric at each location represented by a pattern

box. This sewing is done on the uncoated side of the fabric. Next cut the internal tethers 30 and 31 from 840 denier fabric, the three frangible tethers 31 having a urethane coating. The three urethane coated frangible tethers 31 are sewn at the middle location, surrounded by an endless line 92 of the first three rows. Preferably the stitching that passes through the airbag surface is sealed with a silicone or urethane sealant.

The appropriate length internal tethers 30 should be sewn to each row at the marked locations and sewn on the uncoated side of the airbag fabric. The internal tethers 30 are attached to each sheet of the airbag, effectively securing both sides of the airbag 22 a fixed distance apart when the airbag is deployed. Then sew the perimeter edge 86 of the airbag 22 together except for the throat 54 portion at the bottom of the airbag that should remain open. Next fold the flat, un-inflated airbag 22 in a telescopic fold. The folding begins at the top and proceeds along each marked horizontal line 88 until the folding reaches the fourth row. Then each side of the cross-arm 72 of the T-shaped bag is folded in toward the middle to allow the remaining portion of the airbag 22 to be telescoped up providing the complete packaged airbag. The throat 54 is located at the bottom and will be secured to the module 40 by the holders 82 around its perimeter.

In the preferred embodiment, the pressure in the airbag when fully inflated is between seven and nine pounds per square inch. The airbag 20 is completely deployed in approximately seventy milliseconds. When the airbag becomes almost fully inflated, the internal tethers 31 in the middle of the airbag 22 tend to break forming a bulge in the airbag 22 at substantially the center of the inflated airbag and lowering the internal pressure in the airbag.

By telescoping the un-inflated airbag due to the folding, the airbag 22, during inflation, will come out of the module in an orderly manner, typically with the top of the T-being the first part of the airbag that has broken through the frangible cover 44.

It is understood that the step of marking the horizontal lines 88 on the airbag sheet material 84 may be done automatically by the pattern machine or in the alternative, the stitching machine can be programmed to correctly place the reinforcing strips 90 for securing the internal tethers 30 and 31.

An alternative to the above method is to have two pieces of fabric that are positioned such that one overlies the other. If the desired fabric weight is 840 denier, in this method each sheet can be 420 denier. Each piece of fabric is coated on one side and the uncoated sides face each other. The next step is to weave the two pieces of fabric together. Typically each weave pattern is two or more rows. The rows are transverse to the length of the fabric, i.e. across the width of the fabric. Each group of rows is spaced a predetermined distance from the preceding group. The predetermined distance is equal to one half the initial thickness of the partially inflated airbag as illustrated Fig. 8.

At certain groups of rows, this to be a design decision of the airbag designer, cut through one layer of the cloth creating a flap extending the width of the sheet. Note each flap is held to the double fabric by a group of rows of the weaving. By weaving the two sheets of fabric together there is substantially no leakage through the seam and the seam is substantially flush with the surface of the fabric, wherein a sewn seam will have leakage due to the needle holes and will be a raised seam.

Cut the woven sheet to the desired pattern and size. Take two cut sheets and place the flap sides together. Cut the flaps, which now extend the width of the sheets, to a desired width, having a space between the flaps, and sew the edge of the flaps from one

sheet to the corresponding edge of the other sheet. At this stage, the sewn flaps hold the two outside sheets together. The space between the flaps will allow the inflation fluid to pass. When the flaps are all connected, then sew the perimeter, except for the throat area 59, of the two outside sheets together forming the desired T-shaped airbag. The stitching for the perimeter can be "Double Needle Chain Stitch "DNCS" with 138 Spectra thread. The completed T-shaped airbag is now telescopically folded and put into the module.

What you have at this time is an airbag with the outside surfaces coated, the internal seams are woven together and the perimeter seam is sewn with such a stitch and thread sized to make the airbag substantially leak proof. However, it is known that after a period of time the pressure inside the inflated airbag will cause the inflation fluid to leak off and the airbag will deflate.

Accordingly, various changes and modifications may be made to the illustrative embodiment without departing from the spirit or scope of the invention. It is intended that the scope of the invention, not be limited in any way to the illustrative embodiment shown and described, but that the invention be limited only by claims appended hereto and by the rules and principals of applicable law.

What is claimed:

1. An external airbag system for mounting on a vehicle, said vehicle having a hood and a bumper member forward of said hood facing in a crash direction, said external airbag system comprising:

a housing for storing an airbag within said bumper member, said housing having an opening facing in an upward direction relative to said vehicle in normal operation;

an airbag sized and shaped to be deployed upon inflation above said bumper member for absorbing energy of an impact, said airbag being stored in an uninflated condition within said housing;

a source of pressurized gas for inflating said airbag;

at least one sensor for determining whether an impact is imminent or has occurred; and

a logic circuit responsive to said sensor for providing an initiation signal to initiate said source of pressurized gas for deploying said airbag;

wherein, in response to said initiation signal, said airbag deploys through said opening in an upward direction such that in a deployed condition the majority of the volume enclosed by said airbag is above the bumper member.

2. The external airbag system of claim 1, wherein

said airbag deploys such that substantially the entire volume enclosed by said airbag is above the bumper member.

3. The external airbag system of claim 1, wherein

said airbag deploys such that in a deployed condition the center of volume enclosed by said airbag is behind the leading edge of the bumper region.

4. The external airbag system of claim 1, wherein

said airbag is T-shaped in plan view.

5. The external airbag system of claim 1, wherein:

said airbag comprises a front wall and a rear wall, said airbag further comprising a plurality of internal tethers, each of said plurality of internal tethers being attached between said front wall and said rear wall.

6. The external airbag system of claim 5, wherein:

said plurality of internal tethers comprise at least one frangible internal tether, said frangible internal tether rupturing at a predetermined inflation pressure less than the fully-deployed inflation pressure of said airbag.

7. The external airbag system of claim 1, wherein:

said airbag comprises a front wall and a rear wall, said rear wall having at least two attachment points, one located above the other along said rear wall, said airbag further comprising at least one external tether attached to said two attachment points, the length of said at least one external tether being less than the length of said rear wall

between said two attachment points such that as said airbag assumes a fully deployed condition, said at least one external tether induces a rearward bow in said airbag.

8. The external airbag system of claim 1, wherein:

said housing further comprises a frangible cover for covering said opening.

9. The external airbag system of claim 1, wherein:

said vehicle further comprises a grille area disposed rearward of said bumper member, said airbag being deployed such that in an impact between said vehicle and an object in a crash direction, the majority of the energy of said impact is dissipated by compression of said airbag between said object and said grille area.

10. An external airbag system for a vehicle, comprising:

a housing for storing an airbag on said vehicle;

an airbag capable of being inflated to absorb energy of an impact, said airbag being stored in an uninflated condition within said housing, said airbag in a deployed condition having a T-shaped outline in plan view;

a source of pressurized gas for inflating said airbag;

at least one sensor for determining whether an impact is imminent or has occurred; and

a logic circuit responsive to said sensor for providing an initiation signal to initiate said source of pressurized gas for deploying said airbag;

11. The external airbag system of claim 10, wherein:

said airbag comprises a front wall and a rear wall, said airbag further comprising a plurality of internal tethers, each of said plurality of internal tethers being attached between said front wall and said rear wall.

12. The external airbag system of claim 11, wherein:

said plurality of internal tethers comprise at least one frangible internal tether, said frangible internal tether rupturing at a predetermined inflation pressure less than the fully-deployed inflation pressure of said airbag.

13. The external airbag system of claim 10, wherein:

said airbag comprises a front wall and a rear wall, said rear wall having at least two attachment points, one located above the other along said rear wall, said airbag further comprising at least one external tether attached to said two attachment points, the length of said at least one external tether being less than the length of said rear wall between said two attachment points such that as said airbag assumes a fully deployed condition, said at least one external tether induces a rearward bow in said airbag.

14. An external airbag system for a vehicle, comprising:

a housing for storing an airbag on said vehicle;

an airbag capable of being inflated to absorb energy of an impact, said airbag being stored in an uninflated condition within said housing, said airbag in a deployed condition comprising a front wall and a rear wall, said airbag further comprising a

plurality of internal tethers, each of said plurality of internal tethers being attached between said front wall and said rear wall;

a source of pressurized gas for inflating said airbag;

at least one sensor for determining whether an impact is imminent or has occurred; and

a logic circuit responsive to said sensor for providing an initiation signal to initiate said source of pressurized gas for deploying said airbag.

15. The external airbag system of claim 14, wherein:

said plurality of internal tethers comprise at least one frangible internal tether, said frangible internal tether rupturing at a predetermined inflation pressure less than the fully-deployed inflation pressure of said airbag.

16. An external airbag system for mounting on a vehicle, said vehicle having a front end with a grille area and a bumper member forward of said grille area facing in a crash direction, said external airbag system comprising:

a housing for storing an airbag on said vehicle, said housing having an opening directed toward a region above said bumper member and forward of said grille area;

an airbag sized and shaped to be deployed into said region above said bumper member and forward of said grille area, said airbag being stored in an uninflated condition within said housing;

a source of pressurized gas for inflating said airbag;

at least one sensor for determining whether an impact is imminent or has occurred; and

a logic circuit responsive to said sensor for providing an initiation signal to initiate said source of pressurized gas for deploying said airbag;

wherein, in response to said initiation signal, said airbag deploys through said opening such that in a deployed condition the majority of the volume enclosed by said airbag is above the bumper member and forward of the grille area.

17. The external airbag system of claim 16, wherein

said airbag deploys such that substantially the entire volume enclosed by said airbag is above the bumper member.

18. The external airbag system of claim 16, wherein

said airbag deploys such that in a deployed condition the center of volume enclosed by said airbag is behind the leading edge of the bumper region.

19. The external airbag system of claim 16, wherein:

said airbag comprises a front wall and a rear wall, said airbag further comprising a plurality of internal tethers, each of said plurality of internal tethers being attached between said front wall and said rear wall.

20. The external airbag system of claim 19, wherein:

said plurality of internal tethers comprise at least one frangible internal tether, said frangible internal tether rupturing at a predetermined inflation pressure less than the fully-deployed inflation pressure of said airbag.

21. The external airbag system of claim 22, wherein:

said airbag comprises a front wall and a rear wall, said rear wall having at least two attachment points, one located above the other along said rear wall, said airbag further comprising at least one external tether attached to said two attachment points, the length of said at least one external tether being less than the length of said rear wall between said two attachment points such that as said airbag assumes a fully deployed condition, said at least one external tether induces a rearward bow in said airbag.

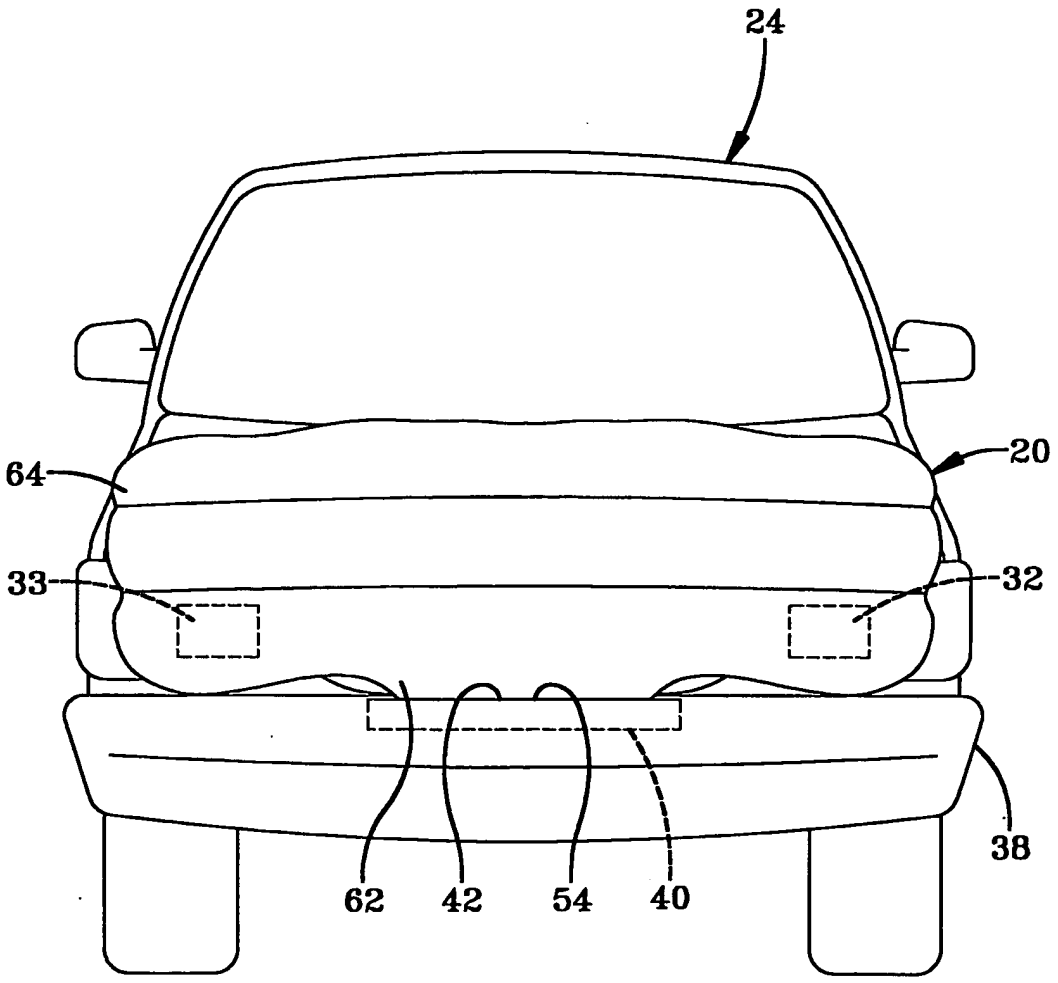

FIG-1

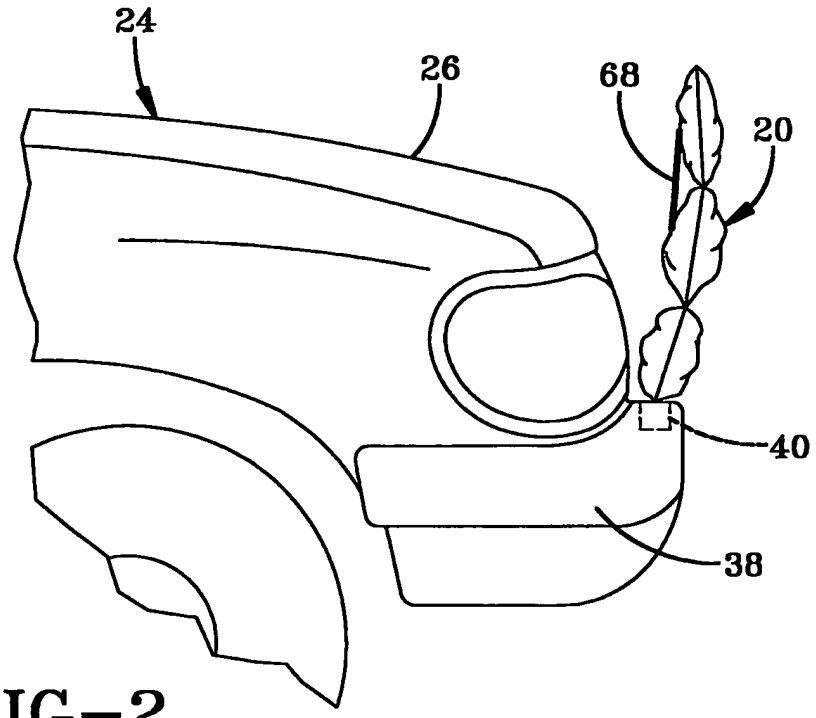

FIG-2

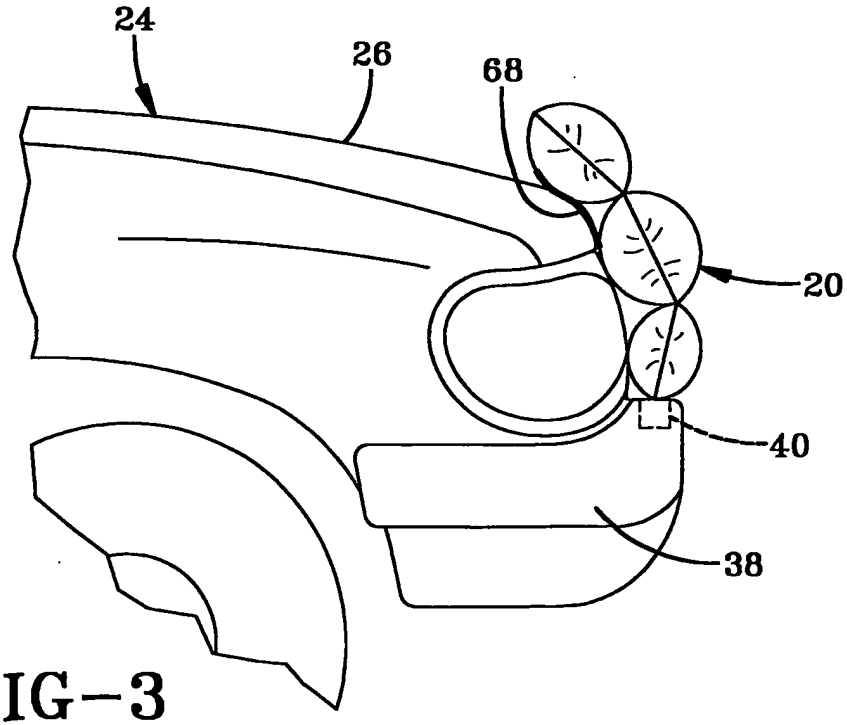

FIG-3

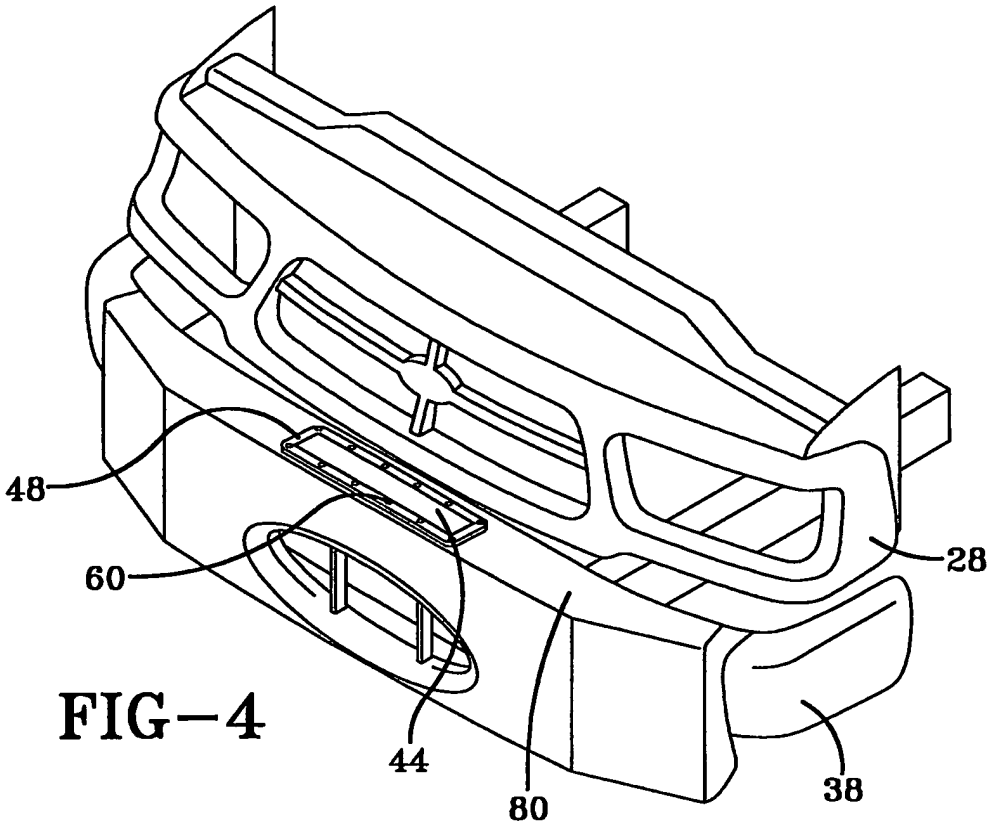

FIG-4

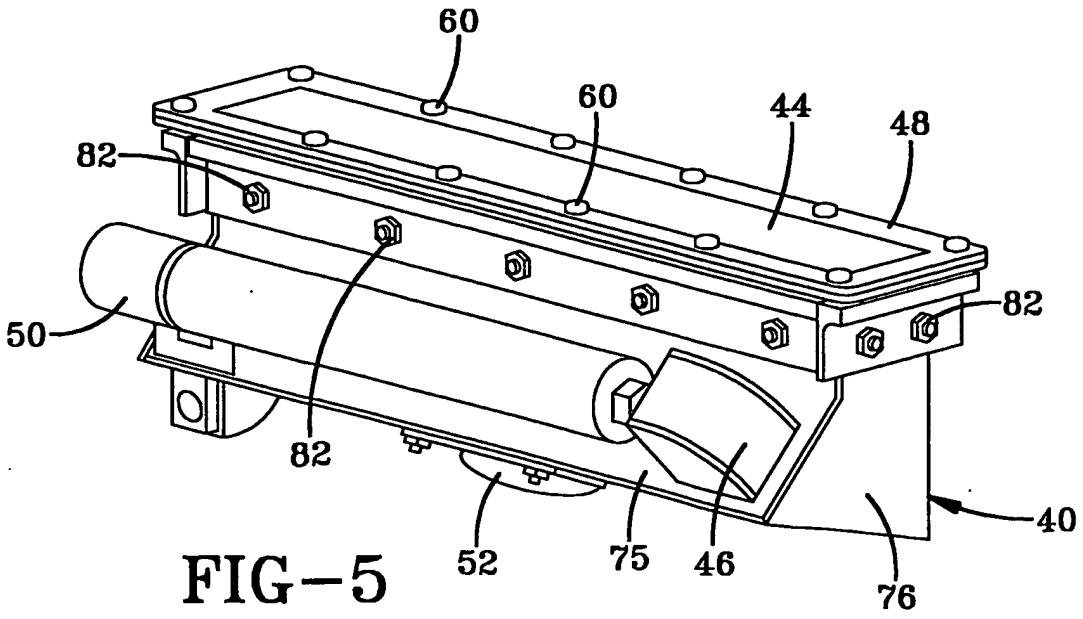

FIG-5

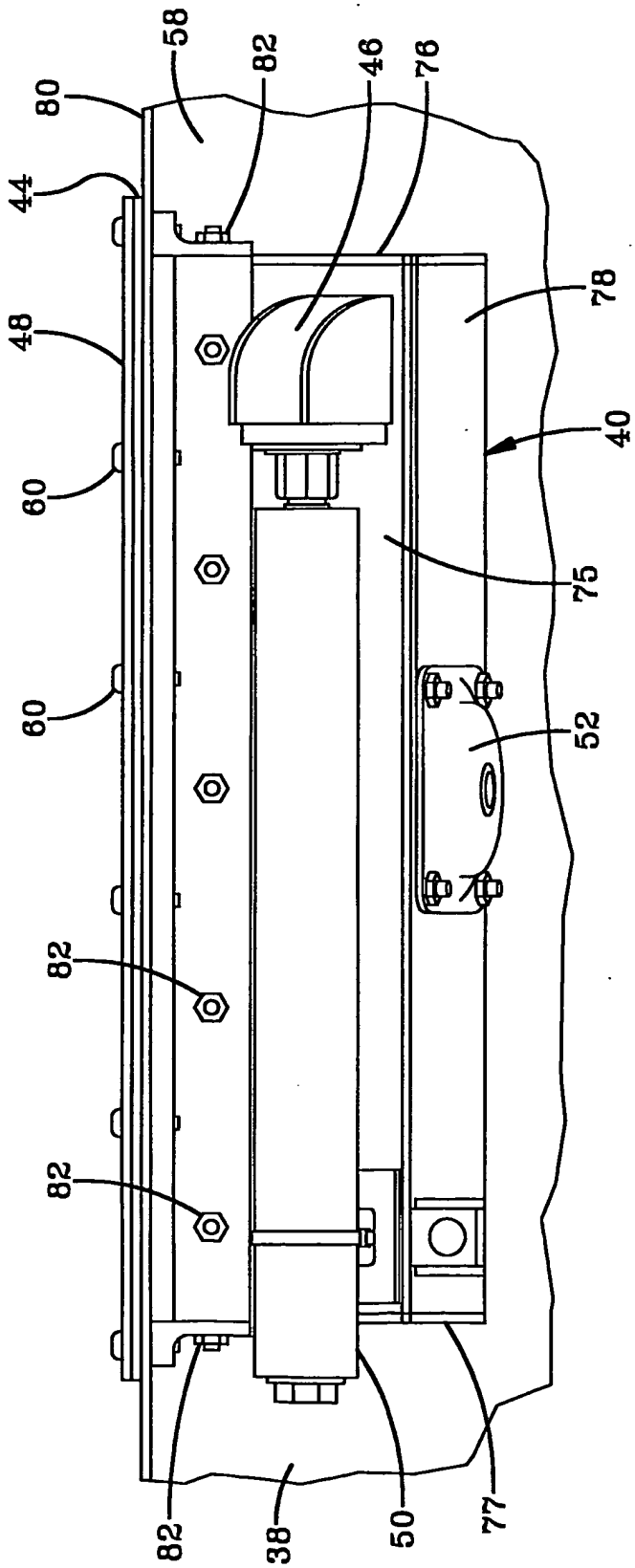

FIG-6

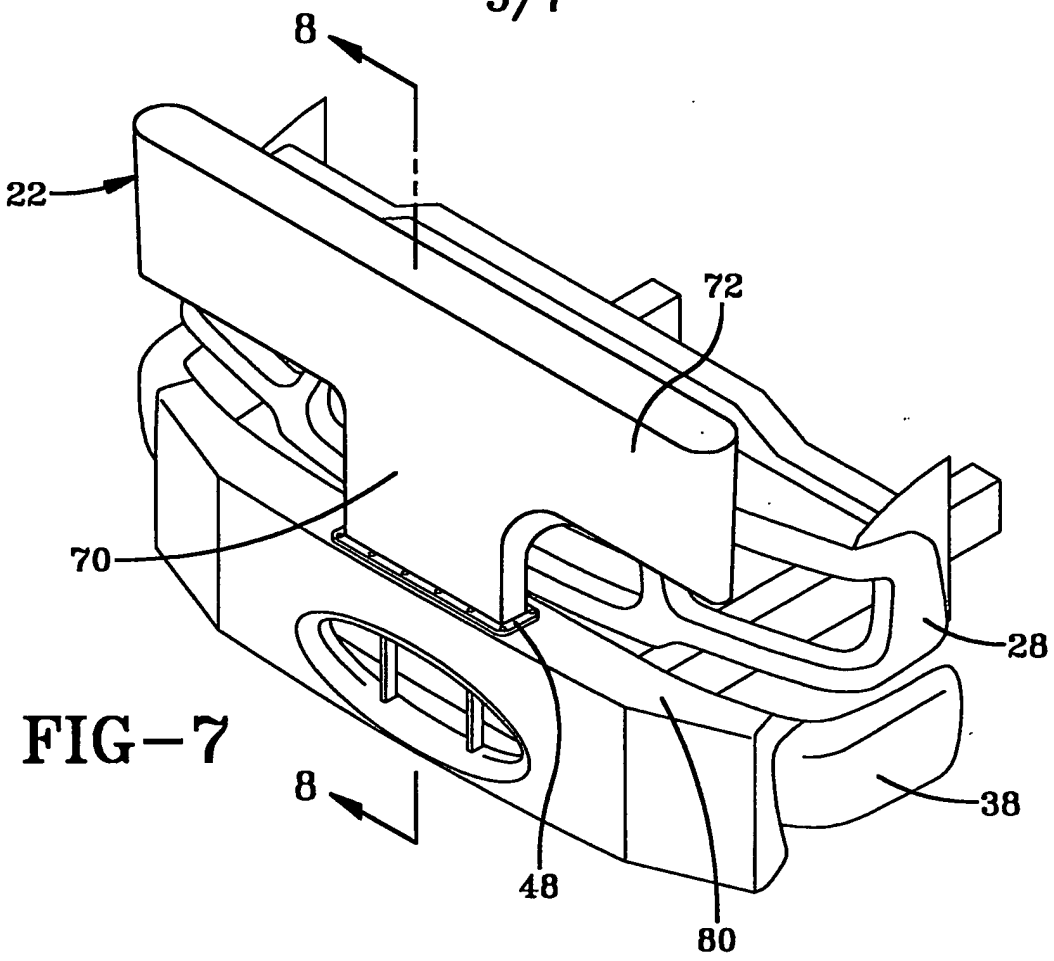

FIG-7

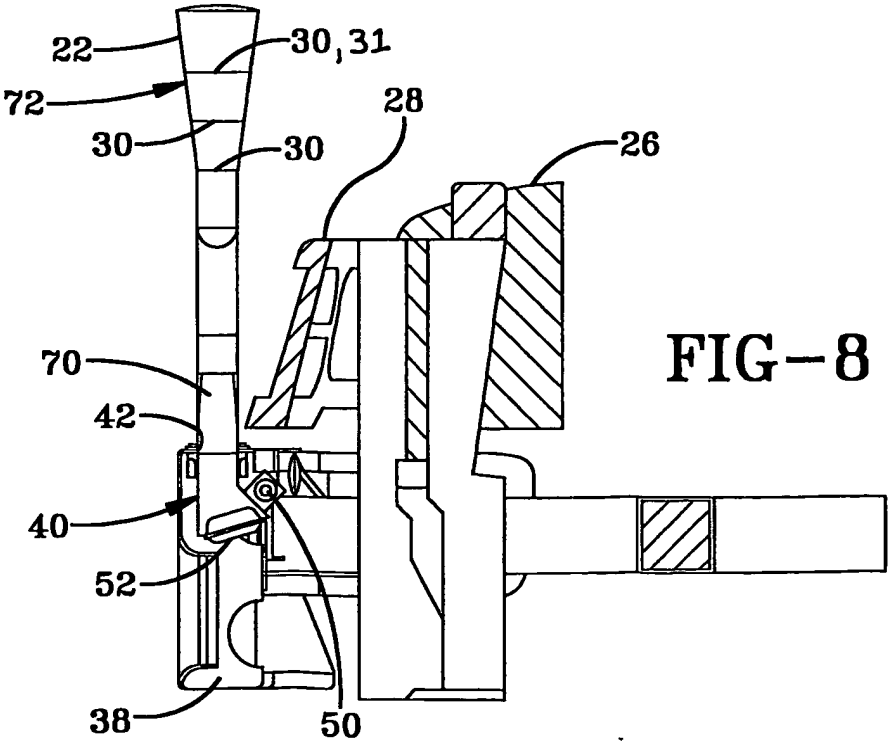

FIG-8

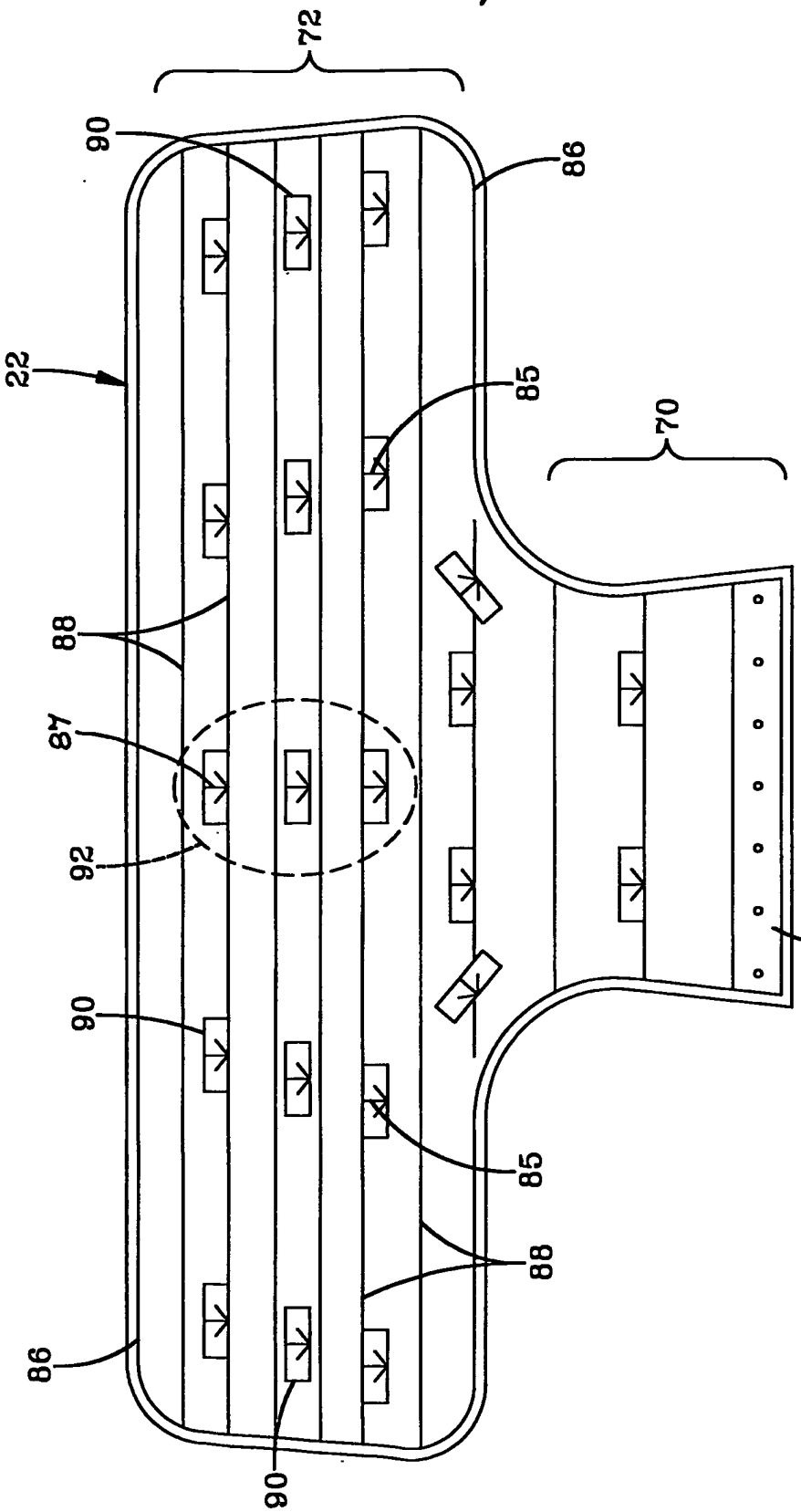

FIG-9

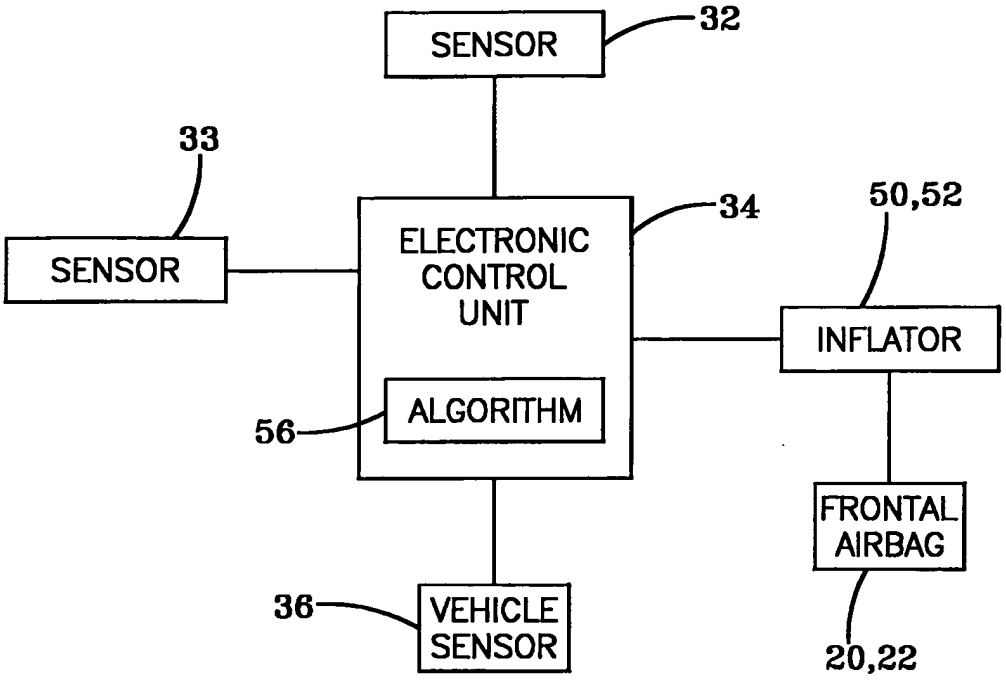
SENSOR
32
33
SENSOR
ELECTRONIC CONTROL UNIT
34
50,52
INFLATOR
ALGORITHM
56
FRONTAL AIRBAG
36
VEHICLE SENSOR
20,22

FIG-10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/40688

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60R21/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 199 18 202 A (BAYER AG) 26 October 2000 (2000-10-26)	1-8, 10-13, 16-21
A	examples 1-3	14,15
Y	US 5 725 265 A (BABER JEFF) 10 March 1998 (1998-03-10) cited in the application column 3, line 66 -column 4, line 10; figures 4,6	1-3,8, 10,14-18
Y	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 08, 30 August 1996 (1996-08-30) -& JP 08 091170 A (TOYOTA MOTOR CORP;TOYODA GOSEI CO LTD; AISIN SEIKI CO LTD), 9 April 1996 (1996-04-09) abstract; figure 5	4,10

-/—

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 March 2003	09/04/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Plenk, R

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 345 669 A (AUTOLIV DEV) 19 July 2000 (2000-07-19) page 8, paragraph 8 -page 12, paragraph 3; figures 2,3	5,6,11, 12,14, 15,19,20
Y	"AIRBAG FOR BUMPER AND LEADING EDGE" RESEARCH DISCLOSURE, KENNETH MASON PUBLICATIONS, HAMPSHIRE, GB, no. 433, May 2000 (2000-05), page 805 XP000976628 ISSN: 0374-4353	7,13,21
A	the whole document	4-6, 10-12, 14,15, 19,20
A	US 5 069 480 A (GOOD STANLEY B) 3 December 1991 (1991-12-03) abstract	1,10,14, 16
A	GB 2 316 371 A (CONCEPT MOULDINGS LTD) 25 February 1998 (1998-02-25) abstract	1,10,14, 16
A	US 3 879 056 A (KAWASHIMA TAKAYOSHI ET AL) 22 April 1975 (1975-04-22) abstract	14

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-9,16-21

an external airbag being deployed upwards against gravity

2. Claims: 10-13

an external airbag having a T-shaped outline in plan view

3. Claims: 14, 15

an external airbag having internal tethers

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 9

Claim 9 attempts to define the subject-matter for which protection is sought by a definition of the result to be achieved. It is not clear what technical features the claimed airbag system must comprise in order to dissipated the majority of the energy of the impact by compression of the airbag. Hence, the claim does not comply with Article 6 PCT.

The application does not contain any technical information as to how this energy dissipation is actually achieved. It also appears that different technical features must be incorporated, depending on the circumstances of the crash, e.g. relative speed and location between the vehicle and the object as well as weight, size and shape of the object. It is not possible to carry out a search for claim 9 because it cannot be established whether this claimed energy dissipation occurs also in the prior art.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 02/40688

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 9
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/40688

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		SK 15142001 A3	05-03-2002
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		JP 856808 C	28-04-1977
		JP 48088629 A	20-11-1973
		JP 51031659 B	08-09-1976

PUB-NO:	WO003053751A1
DOCUMENT-IDENTIFIER:	WO 3053751 A1
TITLE:	VEHICLE FRONTAL AIRBAG SYSTEM
PUBN-DATE:	July 3, 2003

INVENTOR-INFORMATION:

NAME	COUNTRY
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HAILSTONE, STEVEN	US
CURRY, PAUL	US

ASSIGNEE-INFORMATION:

NAME	COUNTRY
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ALEXANDER CHERIE	US
HAILSTONE STEVEN	US
CURRY PAUL	US

APPL-NO:	US00240688
APPL-DATE:	December 19, 2002

PRIORITY-DATA: US34198401P (December 19, 2001)

INT-CL (IPC): B60R021/34

EUR-CL (EPC): B60R021/34

ABSTRACT:

CHG DATE=20030902 STATUS=N>The present invention comprises an external airbag system for mounting on a vehicle (24) that deploys into the region above the bumper (38) to prevent or mitigate injuries that would have otherwise been caused by a person striking the grill (28) or hood area (26) of the vehicle. The airbag (20) is stored in a housing (40) mounted within the front bumper (38) of the vehicle. The airbag (20) is deployed upwardly through an opening (42) in the upper surface of the bumper (38) into the region between the upper surface of the bumper (38) and the front surface fo the grill (28) and hood (26). The airbag (20) is generally T-shaped and includes a plurality of internal tethers (30,31) extending internally between the opposing inner surfaces (74) at regular intervals to cause the airbag (20) to be tufted. The internal tethers (30, 31) reduce the volume of the airbag (20) for a given frontal area thereby decreasing the inflation time required, without resort to fabricating the airbag (20) from multiple idependent chambers. Selected of the internal tethers (31) may be designed to break as the airbag reaches close to its full inflation pressure to allow a portion of the airbag to bulge outwardly after the air bag is fully deployed. The remaining tethers (30) are designed to break as the pressure increases when the airbag is collapsed in a collision.